Arsenic

What Is It? Inorganic and organic arsenic occur naturally in the environment, with inorganic forms being most abundant. Inorganic arsenic is associated with other metals in igneous and sedimentary rocks, and it also occurs in combination with many other elements, especially oxygen, chlorine, and sulfur. Organic arsenic contains carbon and hydrogen. Both inorganic and organic forms exist naturally in soils, plants, animals, and humans. Most pure, inorganic arsenic compounds are white or colorless powders with no specific smell or taste. Because it is an element, arsenic does not degrade nor can it be destroyed.

Symbol:	**As**
Atomic Number: *(protons in nucleus)*	**33**
Atomic Weight:	**75**

How Is It Used? Arsenic has been recognized as a poison since ancient times. In past centuries it was used to treat syphilis, and decades ago it was a common active ingredient in pesticides and was also a common wood preservative. Today, about 90% of arsenic produced is used as a wood preservative (chromated copper arsenate).

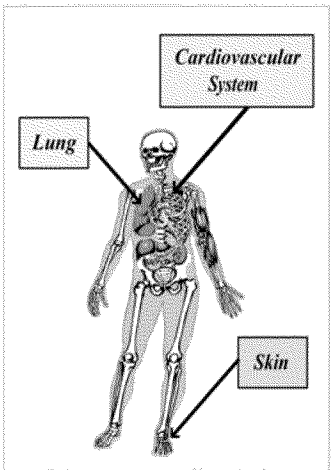
Although organic arsenicals continue to be used as pesticides, primarily on cotton, inorganic compounds can no longer be used. Arsenic is also used as a feed additive for poultry and swine and in cattle and sheep dips to control lice and ticks. In addition, arsenic is used in alloys (primarily in lead-acid batteries for automobiles) and in semiconductors and light-emitting diodes.

What's in the Environment? Arsenic occurs everywhere in the environment. Weathering of rock is the major natural source of inorganic arsenic, and it is also released by human activities. For example, arsenic is emitted as a fine dust when arsenic-containing ores are heated at smelters to process copper or lead. The concentration of arsenic in the earth's crust ranges from 2 to 5 milligrams per kilogram (mg/kg), or parts per million (ppm). The mean natural soil concentration is 5 mg/kg, and it ranges from about 1 to 40 mg/kg. Water-soluble arsenites (the trivalent form, As III) and arsenates (the pentavalent form, As V) are the most common forms. Arsenites especially can be relatively mobile, with a typical concentration associated with soil particles estimated to be 10 to 200 times higher than in the interstitial water (water in the pore spaces between the soil particles). Levels in U.S. drinking water generally average 2 µg/liter, or 2 parts per billion (ppb). Bacteria, fungi, and some plants methylate inorganic arsenic, converting it to organic compounds. Many methylated forms are volatile, such as dimethylarsine. Aquatic organisms in particular can accumulate nontoxic, organic forms of arsenic; for example, levels of arsenobetaine in shrimp are often high. However, the typical ratio of the arsenic concentration in plants to that in soil is low, estimated at 0.006 (or 0.6%).

What Happens to It in the Body? Arsenic can be taken in by eating food, drinking water, or breathing air, and to a limited degree via skin contact. Diet is the primary source of arsenic exposure for most people. Children, and to a lesser extent adults, can also be exposed by ingesting soil. When ingested, dissolved arsenic compounds are readily absorbed (80-90%) through the gastrointestinal tract and distributed in the blood to the liver, kidney, lung, spleen, aorta, and skin. Two processes are involved in arsenic metabolism: (1) oxidation/reduction reactions that interconvert arsenate and arsenite, and (2) methylation of arsenite to form monomethyl arsenic acid and dimethyl arsenic acid. The methylated forms are less toxic and more easily excreted in the urine. Most arsenic is eliminated in the urine within a week (75-90%, depending on the compound), especially from the liver, kidney, and spleen, while that in the skin, brain, skeleton, and especially hair and nails, remains somewhat longer. When arsenic is inhaled and deposited in the lungs, about 80% is absorbed into the bloodstream and distributes throughout the body as above. Arsenic in soil or dissolved in water does not readily penetrate the skin (less than 1% to 3% is estimated to be absorbed, respectively), so dermal exposures are not typically a concern.

What Are the Primary Health Effects? Depending on the amount ingested, arsenic can be beneficial (animal studies suggest that low levels of arsenic in the diet are essential) or adverse (high levels can be toxic). The acute lethal dose to humans can be about 2 to 20 mg/kg body weight per day (mg/kg-day). Ingesting high doses of arsenic irritates the stomach and intestines, with symptoms including nausea, vomiting, diarrhea and liver swelling. However, wide recognition of its toxicity makes arsenic poisoning today very rare. Ingesting small amounts over time produces chronic effects such as skin darkening and formation of corns, damage to peripheral nerves, cardiovascular system effects, hair and appetite loss, and mental disorders. Effects from inhaling arsenic

dust include respiratory irritation, rhinitis, pharyngitis, laryngitis, and sometimes nasal perforation. Skin contact with inorganic arsenic dusts can cause dermatitis, allergic hypersensitivity, and conjunctivitis. Occupational exposure studies show a correlation between chronic arsenic exposure and lung cancer. Arsenic can also cause reproductive/developmental effects, including spontaneous abortions and reduced birth weights. Epidemiological studies indicate an association between arsenic concentrations in drinking water and increased incidences of skin, liver, kidney, lung, and bladder cancers. Studies also show an association between inhaling arsenic and lung cancer. From these data, the U.S. Environmental Protection Agency (EPA) has classified inorganic arsenic as a known human carcinogen. Limited information is available on the joint toxicity of arsenic with other chemicals. For neurological effects, arsenic and lead together can cause effects higher than one alone (greater than additive toxicity), whereas these metals are less toxic to the kidney and hematopoietic (blood-forming) system together rather than alone. The joint toxicity of arsenic and cadmium on the kidney, hematopoietic system, and male reproductive system is also predicted to be less than additive. Additional context for joint toxicity is given in the fact sheet on chemical mixtures.



Primary organs affected when arsenic is inhaled or ingested.

What Is the Risk? The EPA has developed toxicity values *(see box below)* to estimate the risk of getting cancer or other noncancer health effects as a result of ingesting or inhaling inorganic arsenic. These values have been developed based on studies of workers exposed to arsenic in occupational settings, workers applying arsenical pesticides, and populations who drink water containing naturally high concentrations of arsenic. The slope factor is a toxicity value used to estimate the risk of getting cancer from oral exposures, and the value for estimating the risk of cancer following inhalation exposure is called the inhalation unit risk (UR). The UR is an estimate of the chance a person will get cancer from continuous exposure to the chemical in air at a unit concentration, e.g., 1 mg per cubic meter air (m^3). The oral slope factor can be converted to a drinking water unit risk by assuming a 70-kilogram (kg) adult drinks 2 liters (L) of water daily. The EPA estimates a person would have a one-in-a-million chance of developing cancer if the level of inorganic arsenic in their lifetime water supply was 0.02 µg/L. Similarly, using the inhalation UR, EPA estimates a person would have a one-in-a-million chance of getting cancer if exposed daily over a lifetime to 0.0002 µg/m^3 inorganic arsenic in air. The EPA toxicity value used to estimate the potential for noncancer effects following ingestion is the reference dose (RfD), which is an estimate of the dose that can be taken in every day over a lifetime without causing adverse noncancer health effects. To illustrate how the RfD is applied, a 150-pound (lb) person could ingest 0.02 mg arsenic every day without expecting any adverse effects (2.2 lb = 1 kg, or 1,000 g, or 1 million mg). The toxicity value for noncancer effects from inhalation, a reference concentration (RfC), has not been developed. EPA has reviewed existing toxicity values in light of more recent data and released a public draft report in 2010 with draft updates.

Chemical Toxicity Values		
Cancer Risk		**Noncancer Effect**
Oral Slope Factor	***Inhalation Unit Risk***	***Oral Reference Dose***
1.5 per mg/kg-d	4.3 per mg/m^3	0.0003 mg/kg-day

What Are Current Limits for Environmental Releases and Human Exposure? To help track facility releases to the environment, the Superfund amendments for emergency planning and community right-to-know require immediate reporting of a release of 1 lb (0.454 kg) or more of any arsenic compound in a 24-hour period; normal releases are reported annually and entered into the national Toxics Release Inventory. For drinking water, EPA revised its maximum contaminant level from 0.05 to 0.01 mg/L in 2001, with a goal of 0. The Occupational Safety and Health Administration basic standard for inorganic and organic arsenic in workplace air is 0.01 mg/m^3.

Where Can I Find More Information? More information on arsenic can be found in the primary information source for this overview, the Toxicological Profile for Arsenic, prepared by the Agency for Toxic Substances and Disease Registry (ATSDR) (http://www.atsdr.cdc.gov/toxprofiles/index.asp), the ATSDR ToxFAQs (http://www.atsdr.cdc.gov/toxfaqs/index.asp), information developed for the EPA Integrated Risk Information System (http://www.epa.gov/iris with 2010 draft review at http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=219111), and the National Library of Medicine Hazardous Substances Data Bank (http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB).